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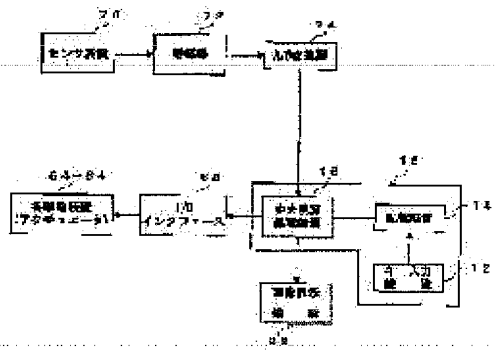
(54) TRAINING DEVICE FOR SUPERIOR LIMB FUNCTION RECOVERY

(57)Abstract:
PROBLEM TO BE SOLVED: To easily execute a function recovery training with a simple configuration by detecting a superior limb action state, calculating an action orbit, guiding the operation of a superior limb support means on the basis of the difference between the action orbit and a target orbit and displaying the coincidence degree of the action orbit with the target orbit.
SOLUTION: The actual action orbit of a superior limb hanging and supporting device is detected by a sensor device 70 including a position sensor and a force sensor incorporated in respective driving a devices 54-64. The result is inputted to the central processing unit 16 of a computer 18 as a digital signal via an amplifier 72 and an A/D converter 74 and the difference between the action orbit and the target orbit is calculated. A driving correction signal based on the result is transmitted to the driving devices 54-64 to correct the orbit of the superior limb hanging and supporting device. The target orbit and the actual orbit are displayed in a monitor image display device 22. Thus a training situation is recognized and grasped to easily execute training.



* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1]A driving means which hangs or raises, and supports an upper extremity, and drives a movable upper extremity support means and said support means, A dead-weight-compensation means to compensate gravity of said support means, a goal setting means to set up a target orbit of said upper extremity, A sensor means which detects an operating state of said upper extremity, an arithmetic processing means which computes difference with an orbit of said upper extremity of operation, and said target orbit based on a signal detected by said sensor means, And an upper extremity functional recovery training device which is provided with a displaying means which displays said orbit of operation and said target orbit on a screen, and is characterized by controlling said driving means based on said difference computed by said arithmetic processing means.
[Claim 2]The upper extremity functional recovery training device according to claim 1 with which said sensor means contains a position sensing device and a force sensor.
[Claim 3]The upper extremity functional recovery training device according to claim 1 or 2 with which said driving means contains a linear drive and a rotary drive.
[Claim 4]The upper extremity functional recovery training device according to any one of claims 1 to 3 with which said dead-weight-compensation means contains a spring member.
[Claim 5]The upper extremity functional recovery training device according to any one of claims 1 to 4 with which said upper extremity support means contains an appliance with which an elbow part and a wrist part of an upper extremity are equipped.
[Claim 6]The upper extremity functional recovery training device according to any one of claims 1 to 5 displayed in the state where said displaying means differ said target orbit and said orbit of operation.
[Claim 7]The upper extremity functional recovery training device according to any one of claims 1 to 6 with which said displaying means displays quantitatively a degree of said orbit of operation to said target orbit.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]Especially this invention relates to the upper extremity functional recovery training device used for that functional recovery training for those who have a handicap in an upper extremity motor function according to the illness or the sequela of a trauma about an upper extremity functional recovery training device.
[0002]
[Description of the Prior Art]As opposed to the brain disorder by the cord injury by the present and a traffic accident, cerebral infarction, cerebral apoplexy, etc., or the physical action disabled person who needs functional recovery training due to the vital function fall of an upper extremity, i.e., an arm, by other causes, Various gradual functional recovery training is generally given to the basis of the help of a physical therapist, a nurse, etc.
[0003]As a device for performing conventionally assistance of those who have a handicap in an upper extremity motor function of operation, For example, the crane mechanism by the arm suspension device which supported the upper extremity with the spring, the upper extremity externally powered orthosis which moves an upper extremity up and down using a line of thread, or a level manipulator and the line of thread moving up and down, etc. are proposed, without using power.
[0004]
[Problem(s) to be Solved by the Invention]However, there is a problem that a device is remarkably complicated with them when kinematic control which cannot control operation of an upper extremity by big flexibility by easy composition and control, and can be satisfied if the device is easy cannot be performed but it can be conversely satisfied with these existing training devices.
[0005]If the form which fixes a training patient's arm to the manipulator driven mechanically in the externally powered orthosis for performing support of spontaneous operation of an upper extremity, a training function, etc. is taken, in order to give a training patient the insecurity of being restrained by machinery, The weight saving of the whole device is attained, removing this insecurity, and to fully consider also about the safety at the time of training operation is desired.
[0006]Functional recovery training (rehabilitation) is accompanied by a bodily pain and mental anguish for a training patient. Since train contents are also repetitions of comparatively monotonous operation, there is a problem that a training patient loses a motivation in many cases.
[0007]So, the main purpose of this invention is easy to constitute, and is providing the upper extremity functional recovery training device with which a training patient can moreover perform functional recovery training freely.
[0008]
[Means for Solving the Problem]An upper extremity support means movable [that hang or raise and this invention supports an upper extremity], A driving means which drives this support means, a gravity guarantee means to guarantee gravity of a support means, A goal setting means to set up a target orbit of an upper extremity, a sensor means which detects an operating state of an upper extremity, An arithmetic processing means which computes difference with an orbit of an upper extremity of operation, and a target orbit based on a signal detected by this sensor means, And it is an upper extremity functional recovery training device which is provided with a displaying means which displays an orbit of operation and a target orbit on a screen, and is characterized by

controlling a driving means based on difference further computed by an arithmetic processing means.

[0009]

[Function]An upper extremity support means is moved by a driving means along the target orbit set up arbitrarily, and the operating state of a actual upper extremity is detected by a sensor means, an orbit of operation is computed by an arithmetic processing means, a driving means is controlled based on the difference of this orbit of operation and a target orbit, and operation of an upper extremity support means is derived. Since the orbit of the upper extremity to a target orbit of operation and its coincidence degree are displayed on a displaying means, training is performed easily.

[0010]

[Effect of the Invention]According to this invention, the training patient can perform functional recovery training movement of an upper extremity reasonable by easy composition. Since the situation of actual training operation is displayed, it becomes possible [a patient] to perform rehabilitation very enthusiastically, and early functional recovery is expected.

[0011]The above-mentioned purpose of this invention, the other purposes, the feature, and an advantage will become still clearer from the detailed explanation of the following examples given with reference to drawings.

[0012]

[Example]In drawing 1, the upper extremity functional recovery training device 10 which is one example of this invention, The key input device 12, the below-mentioned memory storage 14. And the device main frame 28 provided with the supporter 26 prolonged above the pedestal 20 from the pedestal 20 which arranges the computer 18 containing the central processing unit (CPU) 16, the vertical section 24 which is set up from this pedestal 20 and has the image display device 22 for a monitor, and the upper bed part of this vertical section 24, It is hung by this supporter 26 and comprises the movable upper extremity pendant means for supporting 30 in the direction of a three dimension (X, Y, Z). ****** top means for supporting may be used besides the upper extremity pendant means for supporting 30.

[0013]The upper extremity pendant means for supporting 30 are supported by the support frame member 32 and this frame member 32 of the rectangular shape which forms the horizontal supporting section 26 via the pendant link mechanism 40 at the crossing part 38 of the two guide members 34 and 36 constructed over cross shape. This pendant link mechanism 40 comprised the upper extremity supporting link 44 connected with the pendant link 42 and this pendant link, and also the appliances 50 and 52 of belt shape with which the elbow part 46 and the wrist part 48 of the training patient M who performs functional recovery training are equipped are attached to the upper extremity supporting link 44, respectively.

[0014]The linear drives 54, 56, and 58 containing the reversible rotary motor which gives a straight-line motion horizontally (a cross direction and a longitudinal direction) for the upper extremity pendant means for supporting 30 via the pendant link mechanism 40 are formed in each guide members 34 and 36 and the crossing part 38 of those.

[0015]And if the linear drive 54 is driven, the upper extremity pendant means for supporting 30 will move to a cross direction, and if the linear drive 56 is driven, the upper extremity pendant means for supporting 30 will move to a longitudinal direction, and if the linear drive 58 is driven further, the upper extremity pendant means for supporting 30 will move to a sliding direction.

[0016]On the other hand, the appliance 52 of the belt shape which supports the pendant link 42, the upper extremity supporting link 44, and the wrist part 48 of the pendant link mechanism 40 is equipped with the rotary drives 60, 62, and 64 containing the motor which gives the rotational movement which became independent to these. Namely, if rotational movement is given to the pendant link 42 from the rotary drive 60, the upper extremity 66 will be rotated, If rotational movement is given to the upper extremity supporting link 44 from the rotary drive 62, the elbow part 46 will be rotated, and if rotational movement is further given to the appliance 52 of the wrist part 48 from the rotary drive 64, the wrist part 48 can be rotated.

[0017]These are suitably controlled by the computer 18 arranged at the pedestal 20 of the device main frame 28 including the reduction gears with which each linear drives 54-58 and each rotary drives 60-64 are illustrated by neither in addition to a motor, a spring and a damper mechanism and the below-mentioned position sensing device, a force sensor, etc. And the driving force of

each drives 54-64 is transmitted to the upper extremity pendant means for supporting 30 via the mechanism containing a rack, a pinion, and a ball screw. The dead-weight-compensation device with which the pendant link 42 is compensated for the gravity of an upper extremity and which contains a coil spring member for example, it is not illustrated is built into the drive 60 with the force sensor, and dead weight compensation is automatically adjusted by controlling these by the computer 18. Therefore, it is not necessary to adjust beforehand the difference of the dead weight compensation for every training patient everybody, and operation of rehabilitation training etc. can be started. So, when moving an upper extremity in the perpendicular direction, dead weight compensation is not resisting.

[0018]Virtual spring and damper mechanism by the impedance control mentioned later prevent the overload over the upper extremity 66, and changes the permissible dose of the gap from the orbit of the upper extremity 66 of operation by adjusting the size of a spring and a damper ingredient according to the training patient's M condition. When the load more than the full limits of the target orbit set up as an object for training of the upper extremity 66 is applied, a force sensor interrupts training, dispels the restraint of the upper extremity 66, and secures safety. Since the state of an orbit of operation over the target orbit of the upper extremity 66 can be quantitatively treated in the case of training, a medical practitioner and a physical therapist are provided with the judgment source of the training patient's M functional recovery degree, and the volition over a patient's training is promoted.

[0019]A position sensing device gives reproducibility of operation to the upper extremity functional recovery training device 10 by grasping operation of each linear drives 54-58 in the case of moving the target orbit which ran along specific upper extremity operation, and each rotary drives 60-64.

[0020]The device main frame 28 includes the memory storage 14, a power supply, etc. which set up the computer 18 which controls each linear drives 54-58 and each rotary drives 60-64 as mentioned above, a target orbit, etc., A mode change is performed by the key input device 12, and instructions according to the training patient's itself operation, a sound, or a myo electric signal according to a use are also possible for the operating command to the memory storage 14. A training patient, a medical practitioner, a physical therapist, etc. can check the comparison degree to an entry content, the situation of training, a result, and a target, etc. with the monitor image display 22.

[0021]Therefore, the upper extremity pendant means for supporting 30 can perform functional recovery training of an upper extremity, after the training patient has sat on the chair which is not illustrated by the motion control by the combination of a level drive and rotation. Of course, it is also possible for setting out, change, an electronic sound of training time or the number of times of training, etc. to report the end of training time or the number of times of training to a training patient.

[0022]Here, the outline of the impedance control of the upper extremity functional recovery training device 10 is explained.

[0023]First, generation of the target orbit for training an upper extremity sets up the orbit acquired by the calculated standard orbit of operation or teaching.

[0024]And in functional recovery training (rehabilitation) operation (mode). From the current coordinates of the effector (end effector: portion which generally acts on environment by the tip part of a manipulator) obtained from the position sensing device or angle sensor (force sensor) of manipulators (for example, XYZ rectangular cross type manipulator etc.). UV axis is set as a flat surface vertical to a target orbit including these coordinates, it transforms to this in quest of the moving coordinate system UVW which sets W axis as an orbit and a tangential direction, and the position which serves as a target orbit in this coordinates space is searched for. That is, conversion of the coordinate system from X, Y, and Z space to U on the basis of a flat surface vertical to a target orbit, V, and W space is shown in (a) of drawing 2, and (b).

[0025]And in the moving coordinate system UVW, the position of the present effector which makes the starting point the target orbit on the UVW coordinates in a certain time t, i.e., the error from a target orbit, is set to [u (t), v (t), w (t)], respectively.

[0026]The inertia of the upper extremity on which a manipulator and a manipulator act is expressed with the coefficient of inertia J as a mass point of the position of the present effector. The value beforehand measured by parameter measuring mode is used for this coefficient.

[0027]Next, according to the grade of rehabilitation training, the constraint which met the target

orbit in UVW coordinates space is established. As shown in drawing 3, specifically in a flat surface vertical to an orbit (UV flat surface), the coefficient of viscosity D proportional to the displacement from a target orbit or displacement speed and spring-modulus K are set up.
[0028]And only the viscous coefficient D used as the load according to speed is set to the direction of a target orbit, i.e., W shaft orientations. Each parameter is a vector.
It is shown like several 1.

[0029]
[Equation 1]

$$\vec{J} = [J_u, J_v, J_w]$$

$$\vec{D} = [D_u, D_v, D_w]$$

$$\vec{K} = [K_u, K_v, 0]$$

[0030]When a training patient (user) adds power F[of an effector] = [F_u, F_V, and F_W] using the above-mentioned parameter, the equation of motion becomes like several 2.
[0031]
[Equation 2]

$$F_u = J_u \frac{d^2u(t)}{dt^2} + D_u \frac{du(t)}{dt} + K_u u(t) + f_u$$

$$F_v = J_v \frac{d^2v(t)}{dt^2} + D_v \frac{dv(t)}{dt} + K_v v(t) + f_v$$

$$F_w = J_w \frac{d^2w(t)}{dt^2} + D_w \frac{dw(t)}{dt} + K_w w(t) + f_w$$

[0032]Several 3 is another expression of several 2.
[0033]
[Equation 3]

$$\begin{bmatrix} F_u \\ F_v \\ F_w \end{bmatrix} = \frac{d^2}{dt^2} \begin{bmatrix} J_u & 0 & 0 \\ 0 & J_v & 0 \\ 0 & 0 & J_w \end{bmatrix} \begin{bmatrix} u(t) \\ v(t) \\ w(t) \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} D_u & 0 & 0 \\ 0 & D_v & 0 \\ 0 & 0 & D_w \end{bmatrix} \begin{bmatrix} u(t) \\ v(t) \\ w(t) \end{bmatrix} + \begin{bmatrix} K_u & 0 & 0 \\ 0 & K_v & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} u(t) \\ v(t) \\ w(t) \end{bmatrix} + \begin{bmatrix} f_u \\ f_v \\ f_w \end{bmatrix}$$

[0034]Vector $F_g=[f_u, f_v, \text{and } f_W]^T$ of the last paragraph in several 3 is steady load force.
It uses, when giving load fixed at the time of rehabilitation operation or performing dead weight compensation.

[0035]Drawing 4 is a block diagram of an impedance control system of the upper extremity pendant means for supporting 30 in the apparatus 10 which performs rehabilitation along a target orbit using the above-mentioned equation of motion, for example, an upper extremity functional recovery training device.
[0036]An input is a force detection value of the power sensor with which the effector was equipped and which can detect the power of three axes of XYZ at least.
This is changed into a UVW coordinate system by the above-mentioned coordinate conversion, and it asks for $F=[F_u, F_v, F_W]^T$.

[0037]On the other hand, an output is a position of the effector connected to the manipulator. This position is detected and fed back with a position sensing device. From the detected current position, the target position on the orbit beforehand set to rehabilitation (playback operation) is computed, and a current position is changed into the UVW moving coordinate system which makes these coordinates the starting point. And the coordinates acquired by conversion are $[u(t), v(t), w(t)]^T$.
[0038]From the impedance parameter beforehand set to the above controlled variable, the command value of a UVW coordinate system is calculated, it transforms inversely to an XYZ

coordinate system, and a command value is given to a manipulator, i.e., training equipment. And all of these processings are performed by the computer.
[0039]And assistance at the time of a training patient performing upper extremity operation by this, orbital instruction training by controlling each linear drives 54-58 and each rotary drives 60-64 so that a training patient's upper extremity 66 moves on the target orbit decided beforehand, Creation of an orbit required for orbital instruction training by controlling each above-mentioned linear drive and each rotary drive to limit the orbit of a patient's upper extremity voluntary action and these training, etc. are performed.
[0040]Here, each above-mentioned training operation and orbital creation are explained further. Assistance of upper extremity operation : (1) The real time operation by the dead weight compensation over upper extremity operation, a training patient, a care worker, etc., To be able to assist upper extremity operations, such as an orbit by the input of operation of performing the various operation patterns inputted beforehand and fine adjustment of those etc., each linear drives 54-58 and each rotary drives 60-64 are driven, and it controls by the computer 18.
(2) Orbital instruction training by each drive : drive and control each linear drives 54-58 and each rotary drives 60-64 to move on the target orbit 68 where the upper extremity 66 was inputted. And training which repeats movement along the target orbit 68 of the upper extremity 66 in the case of performing a certain operation is performed.
Orbital instruction training by a voluntary action : (3) Only a virtual spring and a damper ingredient are used to an orbital normal line direction so that it may move on the orbit 68 as which the upper extremity 66 which performs a voluntary action was inputted, Each linear drives 54-58 and each rotary drives 60-64 are driven using a power sensor so that a drag may not work to a tangential direction. Thereby, a training patient trains the upper extremity operation which met the target orbit by the voluntary action.
(4) Orbital creation : record the movement track of the upper extremity in the case of performing upper extremity operation which has first a healthy person who does not have a functional disorder in an upper extremity. This performs orbital creation for the various upper extremity operation patterns for assistance of operation, and training, etc.
[0041]That is, equip a healthy person's upper extremity with the appliances 50 and 52 of the upper extremity functional recovery training device 10, a certain specific upper extremity operation is made to perform, and an upper extremity position and speed are detected using a position and a velocity sensor. And orbital creation is performed by recording the operation of each above-mentioned linear drive and each rotary drive to the orbit of operation on the memory storage 14 arranged by the position sensing device at the device main frame 28.
[0042]And according to the orbit created in this way, an original upper extremity function will be gradually recovered by carrying out repeat execution of the functional recovery training of a training patient's upper extremity. Of course, a training patient's measure highly motivated or individual difference cannot generally discuss the grade of functional recovery.
[0043]An outline of operation is explained based on the functional block diagram shown in drawing 5.
[0044]First, the target orbit which operates the key input device 12 and is used as the memory storage 14 of the computer 18 with a training target is selected. Next the training patient M sits on the chair provided in front of the device main frame 28, the elbow part and wrist part of the upper extremity which needs functional recovery training are held with the belt shape appliances 50 and 52 of the upper extremity pendant means for supporting 30, and training is started. As for a dead-weight-compensation device, at this time, dead weight compensation is automatically adjusted with control of the computer 18 according to a training patient based on the rotary drive 60 and a force sensor.
[0045]And a target orbit is read from the memory storage 14, and an actuating signal is outputted from the central processing unit (CPU) 16. This signal is transmitted to each drives 54-58, and 60-64 via I/O interface 68, each above-mentioned drives 54-64 drive it based on this signal, and the upper extremity pendant means for supporting 30 which supported the upper extremity are moved in order that there are along a target orbit.
[0046]however, since the training patient's upper extremity has caused the depression, the actual orbit of the upper extremity pendant means for supporting 30 of operation serves as "gap" ** from a target orbit for a while. The sensor apparatus 70 containing the position sensing device and

force sensor which were built into each drives 54-64 in this "gap" detects, this detecting signal is amplified with the amplifier 72, and it changes into a digital signal with A/D converter 74 further. And based on this digital signal, difference with an orbit of operation and a target orbit calculates with the central processing unit 16 of the computer 18. The drive correcting signal based on this difference is transmitted to each drives 54-64 via I/O interface 68 from the central processing unit 16, and each drive operates so that the orbit of the upper extremity pendant means for supporting 30 of operation may be corrected and a target orbit may be approached.

[0047]The target orbit and the actual orbit of operation of the upper extremity pendant means for supporting 30 are displayed on the image display device 22 for a monitor from the central processing unit 16, and since the correction orbit based on the difference of both orbits is also fed back and displayed, the training patient can carry out the recognition grasp of the training condition immediately by vision.

[0048]It is also possible to also set simultaneously working speed, the number of times of training, and training time as a computer as mentioned above as a training target in addition to a target orbit, and to display on the image display device 22 for a monitor.

[0049]An operation situation is explained based on the flow chart shown in drawing 6.

[0050]First, a power supply is switched on and started. The dead weight compensation of the upper extremity held at Step S1 at the upper extremity pendant means for supporting 30 is adjusted automatically. Next, at Step S3, the performance information of the upper extremity held with the upper extremity pendant means for supporting 30 by the sensor apparatus 70 is detected. At Step S5, it changes into a patient's orbit of operation by computer 18 based on the performance information detected at Step S3. At Step S7, the difference of the target orbit currently recorded on the memory storage 14 of the computer 18 and the orbit of operation changed at Step S5 is computed with the central processing unit 16.

[0051]And based on the difference computed at Step S7 in step S9, the correction value of an orbit of operation is further calculated with the central processing unit 16, and each drive (actuator) control is performed at Step S11 via I/O interface 68 based on the invitation for amendment. In Step S13, the operation adjustments which approach a target orbit based on actuator control in the orbit of the upper extremity pendant means for supporting 30 of operation are performed, and a series of operations are completed (end). winding this the operation of a series of henceforth -- ****** -- a patient's upper extremity functional recovery training is performed by things.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is an illustration figure of the outline composition of the upper extremity functional recovery training device in which one example of this invention is shown.
[Drawing 2](a) And (b) is an approximate account figure showing conversion of the coordinate system in the impedance control of an upper extremity functional recovery training device.
[Drawing 3]It is an explanatory view showing the constraint which met the target orbit in UVW coordinate system space according to the grade of rehabilitation training.
[Drawing 4]It is a block diagram of an impedance control system of an upper extremity functional recovery training device which performs rehabilitation along a target orbit.
[Drawing 5]It is a functional block diagram of the upper extremity functional recovery training device in this example.
[Drawing 6]It is a flow chart which shows the flow of the operation outline in drawing 5.
[Description of Notations]
10 -- Upper extremity functional recovery training device
12 -- Key input device
14 -- Memory storage
16 -- Central processing unit (CPU)
18 -- Computer
22 -- Image display device for a monitor
28 -- Device main frame
30 -- Upper extremity pendant means for supporting
50 and 52 -- Appliance
54, 56, and 58 -- Linear drive
60, 62, and 64 -- Rotary drive
68 -- I/O interface (input/output interface)
70 -- Sensor apparatus (a position sensing device and a force sensor are included)
72 -- Amplifier
74 -- A/D converter

[Translation done.]